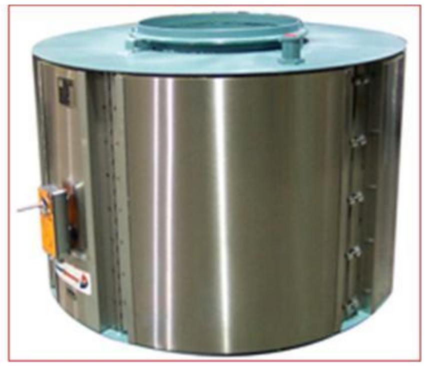
Use of Non-Condensing Economizer on a Boiler

Prepared for California Energy Commission (CEC)

Prepared By:

Southern California Gas Company
(A Sempra Energy Utility)

E3M Inc.

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Executive Summary

This calculator tool can be used to estimate annual energy savings and the associated cost (US dollars) savings and subsequent reductions in CO_2 emissions through use of a feed water economizer that allows recovery of heat from boiler flue gases. Recovery of heat from boiler flue gases can substantially reduce the energy consumption for the boiler.

In a typical system, as shown in Exhibit 1, a gas to liquid heat exchanger is used to transfer heat from the flue gases to the feed water. The flue gas comes into contact with the outer heat transfer surface (usually a bank of finned tubes) and transfers heat to water flowing inside the tubes which results in a rise in water temperature. Using higher temperature water reduces the heat requirement in the boiler and results in an overall efficiency increase. Actual savings depend on several factors such as the increase in water temperature, current efficiency of the boiler, steam pressure and steam temperature at the outlet of the boiler. For most small to medium size boilers, the energy savings can be in the range of 3% to 10% of the current energy use.

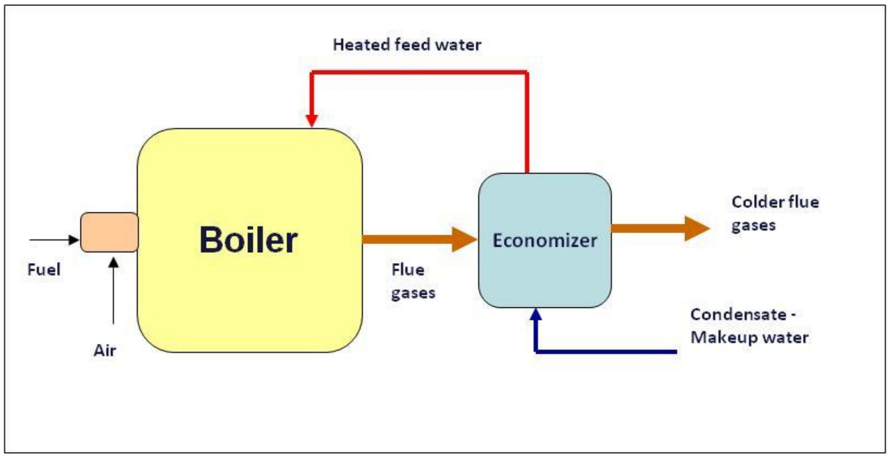

Exhibit 1: Typical boiler flue gas heat recovery system

This calculator estimates the annual energy savings in terms of millions of British Thermal Units (MMBtu/year). It also estimates the energy cost reduction using the given cost of fuel and the number of operating hours per year.

The amount of CO_2 emissions reduced is also estimated using natural gas as the sole fuel source.

The primary objective of this calculator is to identify energy savings potential in industrial heating operations to make a go / no go decision on further detailed engineering and economics analysis. The user is required to give data for several operating parameters that can be measured or estimated from normal operating conditions using available records. All data should be collected at typical or average unit operating conditions.

Calculator results should be considered preliminary estimates of energy savings potential and a starting point for more detailed technical and economic analysis. The accuracy of the calculator's results is expected to be within ±5 percent

Note to the user of this calculator Tool

Use of this tool requires knowledge and operation of boilers. The user is referred to several training programs and references quoted at the end of his document for further information on the available resources for getting trainings that would provide additional knowledge for the subject matters discussed in this document.

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LIST OF EXHIBITS

1. Description of the subject area

This technical guide describes a calculator tool that will allow a user estimate annual energy (fuel) savings, reductions in CO_2 emissions, and energy cost savings ($/year) with the use of an economizer to preheat boiler feed water. This efficiency measure can offer substantial savings in energy use for the boiler resulting in reduction in boiler operating cost.

Steam generation in a boiler requires feed water that is often a mixture of returned condensate and treated make up water. The amount of makeup water that enters the steam system depends on how much condensate is returned to the boiler. In spite of all economically justifiable efforts to return as much condensate back to the boiler as possible, an amount of makeup water is always required for the boiler. Using cold makeup water and accounting for heat losses from condensate return system results in feed water temperature that is lower than the boiling point of water at the boiler operating pressure. In many cases, the feed water is heated in a deaerator but its temperature can be substantially lower than boiling temperature of feed water at the boiler pressure.

Using an economizer can increase feed water temperature and reduce the amount of heat required in a boiler. The amount of heat that can be transferred and the upper limit of feed water temperature depends primarily on boiler (steam) pressure and temperature of flue gases discharged from the boiler. Transferring heat from the flue gases to the feed water will lower flue gas temperature. If the flue gas temperature drops too low, then it is possible that water vapor in the flue gases can condense on colder areas or spots for the economizer. Condensation of flue gas water vapor typically results in the corrosion of the metal used in the economizer. For natural gas fired boilers the lowest recommended flue gas temperature coming out of an economizer is about 200 °F. It is possible to recover additional heat from flue gases by condensing water vapor content of flue gases. However, this requires use of specially designed heat exchanger and requires that water be used for areas other than steam production. In many small boilers, it is difficult to justify use of condensing heat exchanger unless there are special considerations.

As shown in Exhibit 2 an economizer is installed on a flue gas stack or at an appropriate location attached to the boiler so that flue gases pass through the economizer. In most commonly used designs the economizer is constructed by using finned tubes of carbon steel or higher grade steel. Presence of fins on the outside of the tubes increases the heat transfer rate from the flue gases to the water. The tube selection and configuration depends on the boiler pressure, available space and other local considerations. In most cases, a flue gas by-pass is used.

The calculator is used to estimate annual expected energy savings in terms of millions of British thermal units (MMBtu/year). It also estimates the energy savings by using the given cost of fuel and the number of operating hours per year. Additionally, this calculator gives the reduction in CO_2 emissions that result from application of the suggested energy saving measure.

A brief summary of the important parameters is as follows:

Current boiler energy use: This is the average amount of energy used at typical boiler operating conditions selected.

Boiler operating hours (hours/year) – This is the total number of hours for which the boiler is operated based on a recent 12-month period.

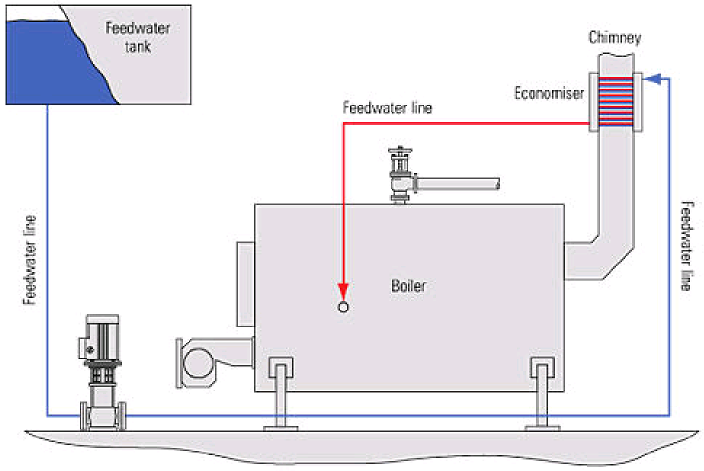

Exhibit 2: Components of a boiler economizer installation (Courtesy Spirax Sarco)

Boiler operating conditions – This includes boiler (steam) pressure in psig, flue gas and combustion air temperatures in °F, oxygen percentage (on dry basis) in flue gases, and boiler efficiency in percentage. This information can be obtained from the records and flue gas analysis conducted at typical or average boiler operating condition. .

Feed water information – This includes information amount the feed water temperature (°F) and flow rate (gallons per minute – gpm or lbs/hour) as it enters the boiler at current and average or typical operating condition selected.

Economizer or heat exchanger information – Economizer or heat exchanger effectiveness expressed as percentage. This information should be obtained from the supplier. For initial trials, one can use any value between 50% and 70%. The value may have to be changed after reviewing the results. This includes feed water temperature (°F) and flow rate (gallons per minute – gpm or lbs/hour) as it enters the boiler at current and average or typical operating condition selected.

Cost of fuel - The average fuel cost ($/MMBtu) based on the history and, if possible, future projected cost based on contacts with the energy supplier.

2. Impact of using a feed water economizer on energy savings and CO2 emissions

This calculator allows a user to estimate energy (fuel) savings that can be achieved by using an economizer to recover heat from flue gases to preheat boiler feed water. This fuel saving has a corresponding reduction in CO_2 emissions. All commonly used fossil fuels such as natural gas result in the formation of CO_2. The reduction in CO_2 emissions is directly proportional to the amount of natural gas usage reduced.

The energy savings can vary from 3% for boilers with low temperature flue gas to 10% where boiler flue gas temperature is high enough to recover larger percentage of heat. Annual energy cost savings depend on the cost of energy, expressed as US dollars per MM Btu. The exact value of savings can be estimated by using this calculator.

The CO_2 savings are directly related to energy savings. According to U.S. Environmental Protection Agency (EPA) estimates (Reference 5), the combustion of natural gas used in USA produces 116.39 lbs of CO_2 per MM Btu heat input. For convenience, most calculations use 117 lbs CO_2 emission per MM Btu heat input from natural gas. If the natural gas composition is available, it is advisable to carry out detailed combustion calculations to estimate value that is more accurate for the CO_2 produced by the combustion of natural gas. Reduction in CO_2 emissions is calculated by using the value of reduction in energy (fuel) used for the furnace.

3. Discussion on the technical approach and the calculations

Heat recovery from boiler flue gases will result in energy savings by increasing the feed water temperature and reducing in heat required in a boiler. The main incentive for this measure is to reduce energy use and correspondingly reduce emission of Green House Gases (GHGs) such as CO_2 and NO_x.

There are several methods available to recover heat from boiler flue gases. They include feed water heating and combustion air preheating. For steam systems, feed water heating offers more energy savings per unit of heat recovered than combustion air. The exact savings amount is dependent on the flue gas temperature and degree of heat recovered by the economizer used to preheat feed water. Preheating of feed water by using heat from flue gases reduces flue gas heat loss and increases boiler efficiency.

Heat recovered by feed water preheating depends on the feed water flow rate, usually expressed in terms of gallons per minute or lbs. per hour and temperature rise in the economizer.

Where

= heat recovered in feed water from flue gases (Btu/hour)

= mass flow of feed water (lbs./hour)

= feed water temperature at the outlet of the economizer (^{0}F)

= feed water temperature entering the boiler without use of economizer (^{0}F)

The value of depends on the heat economizer (heat exchanger) effectiveness ( ).

The heat exchanger effectiveness value depends on the heat exchanger design and size, and it has to be obtained from the economizer supplier. For the purposes of estimating energy savings, a value of 50% to 70% is appropriate evaluate range of savings.

Total heat transferred to feed water can be calculated by using value of and total heat that can be recovered from flue gases.

Total amount of recoverable heat can be calculated by using values of standard volume (or mass) flow rate that depends on the boiler firing rate, excess air used for combustion based on flue gas oxygen reading, flue gas temperature and specific heat of flue gases. In this calculator, the calculations are done by using volumetric flow rate (standard cubic feet per hour) and following values for the parameters are required.

Average heating value ( ) of natural gas = 1,030 Btu/(SCF)

Stoichometric air/fuel ratio for the combustion of natural gas = 10 scf per scf of natural gas.

Specific heat of flue gases ( ) = 0.021 Btu/(scf of flue gas)

Total volume flow rate for flue gases ( ) depends on the boiler firing rate ( ) and the amount of excess air used for combustion.

Value of excess air can be obtained by measuring oxygen (O_2) content (on a dry basis) in flue gases. For natural gas and most commonly used fuels, relationship between O2 in flue gases and excess air is well established and it is given in the following Exhibit 3.

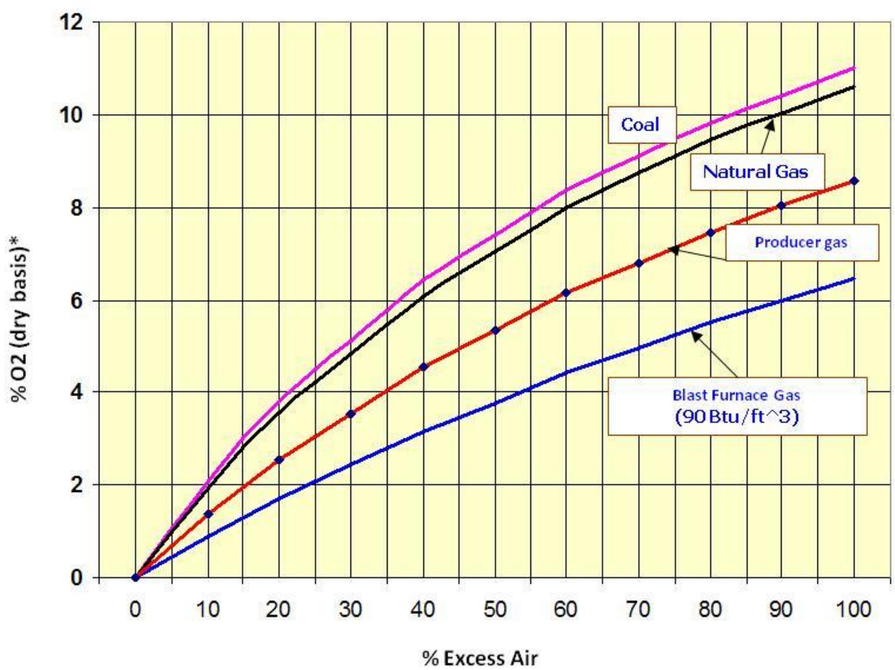

Exhibit 3: Relationship between % oxygen and excess air in flue gasses

Where

= Total heat input to boiler in MMBtu/hour

= heating value (higher) of fuel (natural gas) in Btu/[std. cu.ft. (scf)]

Xsair = Excess air calculated based on O2 in flue gases in percentage (%).

The maximum amount of transferable heat is the minimum of the following two quantities.

Maximum possible heat transfer from gases to water is equal to the total heat content of flue gases at temperature (°F) is calculated as

Where

= Flue gas temperature from boiler to economizer

= Water temperature entering the economizer

– Specific heat of water (Btu/lb-F) and its value is 1.0

=

- = heat transferred to fed water (Btu/hr)

= hot feed water temperature

= cold flue gas temperature discharged from the economizer

Note that the hot feed water temperature must be lower than the boiling point of water at boiler steam pressure and the cold flue gas temperature leaving the economizer must be lower than the condensation temperature of flue gases (estimated conservatively at 200 °F).

= Boiler efficiency expresses as ratio of heat content of steam generated per hour and heat input to the boiler. This value can be in the range of 65% to 85%.

Annual savings (MMBtu/year) are calculated by using value of savings per hour, annual operating hours and converting Btu to MMBtu.

Cost savings are calculated by multiplying annual savings and cost of fuel expressed as $/ MMBtu.

CO_2 savings are based on 117 lb. of CO_2 generation per MMBtu firing rate or energy use assuming that the fuel is natural gas.

4. Instruction on use of the calculator

The following list summarizes the user inputs that are required. The user should collect this information before using this calculator tool:

- Company name, plant location and address
- Customer name and contact information

- Heating equipment description (where the energy-saving measure is applied)
- Equipment type (furnace, oven, kiln, heater, boiler)
- Equipment use (e.g., textile drying, aluminum melting, food processing)

Note that some of this information may be optional for the web-based calculators due to users' concerns about privacy.

The following input data is required from the user:

- Current boiler energy use – average value (MMBtu/hour)
- Boiler operating hours per year (hours/year)
- Flue gas temperature (hot side inlet) to the economizer (heat exchanger) (°F)
- Oxygen in flue flue gas (% dry basis).
- Water (cold side) flow rate – to economizer (lbs/hour)
- Water pressure (psig)
- Water (cold-side) inlet temperature (°F) – to economizer
- Boiler efficiency (%).
- Heat exchanger effectiveness (%).
- Energy (natural gas) cost ($/MMBtu)

The calculator gives following results:

- Flue gas (hot side) outlet temperature from economizer (°F)
- Water (cold side) outlet temperature from economizer (°F)
- Energy savings (%)
- Annual Energy savings (MMBtu/year)
- Annual energy or fuel cost savings ($/year)
- CO_2 savings (Tons/year)

This calculator requires the following input parameters describing the heating process in order to estimate the savings. Exhibit 4 shows the user information screen and Exhibit 5 shows the calculator screen.

The first section requires information about the user, equipment, and process.

Line 1 – <u>Name of the company</u>

Line 2 – <u>Name or known designation such as "main plant" or "secondary plant" if applicable</u>

Use of Non-Condensing Economizer for a Boiler					
1	Company name	ABC Corporation			
2	Plant name or designation	LA Plant			
3	Plant address	12345 Main Street, Gabriel, CA 90878			
4	Contact name	Bob Smith			
5	Contact address	54321 First Street, North Warren, CA 90878			
6	Contact phone number	Phone:	916-756-9923	E-mail:	b.smith@abccorp.com
7	Date (format mm/date/year)	May 12, 2010			
Heating equipment description (where the energy saving measure is applied)					
8	Equipment type (e.g. furnace, oven, kiln, heater, boiler)			Boiler	
9	Equipment use (e.g., textile drying, aluminum melting)			Gas fired boiler	
10	Other comments if any	The boiler is used continuously.			

Exhibit 4: Required information for the calculator user

Line 3 – Plant address

Line 4 – Contact name for the plant – This individual is main contact and is responsible for collecting and providing the required information.

Line 5 – Address for the contact person

Line 6 – Contact phone number and e-mail to be used for all future communications

Line 7 – Date when the calculations are carried out

Line 8 – Type of heating equipment – This can be an oven, furnace, boiler, heater, etc. This is the heating equipment where data is collected and the given energy saving measure is to be applied.

Line 9 – Process or function for which the heating equipment is used – This can be name of the process such as drying, melting, water heating, etc.

Line 10 – Any additional information that can be useful in application of the results

The second section of the calculator is used for collecting the necessary data and reporting the estimated savings.

Exhibit 5 shows the required data for the calculator. The calculator cells are color coded. The white color cells are used for data input by the user while the colored (yellow and light blue or green) cells are protected and give results of the calculations. The user is not allowed change numbers shown in the colored cells.

Line 11 – Current boiler energy use (MMBtu/hour) – Give value of average energy use or energy use at a specific operating condition for the boiler. In many cases, this represents average value for energy use.

Line 12 – Boiler operating hours per year (hours/year) – Give number of operating hours per year for the boiler.

Line 13 – Flue gas temperature (hot side inlet) to the economizer (heat exchanger) (°F) – This is a measured value and can be obtained by flue gas analysis or in some cases it may be available from the boiler control room instruments.

Use of a Non-Condensing Economizer for a Boiler			
The tool is applicable to economizers and other flue-gas-to-water heat exchangers *when the water vapor in flue gas is not condensed and heat exchanger effectiveness is known* .			
11	Current boiler energy use - ***average value***	25	MM Btu/hr
12	Boiler operating hours per year	7,000	Hrs./year
13	Flue gas temperature (hot-side inlet) to the economizer	450	Deg. F.
14	Oxygen in flue gas (%, dry basis) from the boiler	4.0%	%
15	Excess air (%)	22.1%	%
16	Feed water (cold-side) water flow rate	15,000	lbs./hr
17	Feed water (cold-side) water flow rate	30.00	gpm
18	Feed water (cold-side) pressure	150	psig
19	Feed water (cold-side) inlet temperature	60	Deg. F.
20	Displaced hot water (deaerator) heater efficiency (%)	80%	%
21	Economizer (Heat exchanger) effectiveness (%)	60%	%
22	Heat transferred to cold feed water	1,576,165	Btu/hr.
23	Flue gas (hot-side) outlet temperature	216	Deg. F.
24	Feed water outlet temperature	165	Deg. F.
25	Energy savings (%)	7.9%	%
26	**Annual energy savings**	**13,791**	**MM Btu/year**
27	Energy (natural gas) cost	$6.00	$/MM Btu
28	**Annual cost savings**	**$82,749**	**$/year**
29	**Annual CO2 savings based on natural gas as fuel**	**807**	**Tons/year**

Exhibit 5: Example of calculator inputs and results

Line 14 – Oxygen in flue flue gas (% dry basis) – This is a measured value and can be obtained by flue gas analysis. Note that this is a value based on dry flue gas analysis. and most modern analyzers will give this value.

Line 15 – Excess air (%) – This is a calculated value based on use of natural gas as fuel.

Line 16 – Feed water (cold side) flow rate (lbs/hour) – Give value of water flow to the economizer. This is a measured value or its approximate value can be obtained if the steam generation rate plus blowdown rates is known, and if all feed water going to the boiler is passed through the economizer.

Line 17 – Feed water (cold side) flow rate (gpm) – Calculated value based on the mass flow rate input on line 16.

Line 18 – Water pressure (psig) – Give value of feed water pressure as it enters the economizer or boiler. In cases where it is not available directly it may be possible to use steam pressure as an approximate value.

Line 19 - Water (cold-side) inlet temperature (°F) – Give the temperature of feed water entering the economizer. This value can be measured or may be available on a temperature gage on the pipe or in the boiler control room.

Line 20 – <u>Displaced hot water (deaerator) heater efficiency (%)</u> – This should be obtained from an deaerator supplier. If it is not possible to get this value then you may use nominal value between 80% and 100% for commonly used deaerators. Note that this would be an approximate value and should not be considered as final and very accurate.

Line 21 – <u>Heat exchanger effectiveness (%)</u> – This should be obtained from an economizer supplier. If it is not possible to get this value then you may use nominal value between 50% and 60% for commonly used economizers. Note that this would be an approximate value and should not be considered as final and very accurate.

Line 22 – <u>Heat transferred to cold feed water (Btu/hr)</u>. This is a calculated value and it represents heat added to feed water as it passes through the economizer. See section 3 of this Technical guide for calculation method used.

Line 23 – <u>Flue gas (hot side) outlet temperature (°F)</u> – This is calculated value and represents flue gas outlet temperature from the economizer.

Line 24 – <u>Water (cold side) outlet temperature (°F)</u> – This is calculated value and represents temperature of heated feed water at the outlet of the economizer.

Line 25 - <u>Energy savings (%)</u> – This is calculated value based on heat transferred from the boiler flue gases to feed water, boiler efficiency (total energy saved) and current energy use. It is ratio of total energy saved after allowing for boiler efficiency and current energy use for the boiler.

Line 26 – <u>Annual Energy savings (MMBtu/year)</u> – This is calculated value based on data given in Lines 11, 12 and 24 above.

Line 27 – <u>Energy (natural gas) cost ($/ MMBtu)</u> – The user gives cost of fuel expressed in terms of $/MM Btu. The cost should include all charges related to use of fuel at "the burner tip". This value can be obtained directly from monthly or annual gas bills. It is often stated as a line item on the bill. If the bill does not specifically mention the gas cost then it is necessary to calculate average cost of fuel by using values of total fuel cost and annual fuel used.

If necessary, contact the fuel (natural gas) supplier or distributor for more information.

Line 28 – <u>Annual energy or fuel cost savings ($/year)</u> – This is calculated value based on data given in Lines 25 and 26 above.

Line 29 - <u>Reduction in CO_2 emissions (tons/year)</u> – These savings are calculated based on annual fuel savings, assuming the fuel used is natural gas. The savings are in Short (US) tons, not Metric tons.

Note that the CO_2 savings are based on natural gas as the fuel for the heating equipment. A correction factor must be applied if any other fuel is used.

5. References and Resources

1. Web site: http://www.spiraxsarco.com/resources/steam-engineering-tutorials/the-boiler-house/heat-recovery-from-boiler-blowdown.asp
2. *Unit Conversions, Emission Factors, and Other Reference Data*, published by the U.S. EPA, November 2004. Available online at http://www.epa.gov/cpd/pdf/brochure.pdf
3. *North American Combustion Handbook*, Third Edition, 1986. Published by North American Mfg. Company, Cleveland, OH.
4. *Improving Process Heating System Performance: A Sourcebook for Industry*, U.S. Department of Energy. Available online at

http://www1.eere.energy.gov/industry/bestpractices/pdfs/steamsourcebook.pdf

5. *SCAQMD PROTOCOL: Improvement of the Efficiency of a Natural Gas-Fired Boiler or Process Heater (Draft)*, version 2, March 2009. Published by SCAQMD.
6. *Tip sheets and Technical Briefs*, published by The U.S. Department of Energy. Available online at

   http://www1.eere.energy.gov/industry/utilities/steam_tools.html

7. Training opportunities for process heating technology
   - The U. S. Department of Energy (DOE), Energy Efficiency and Renewable Energy (EERE) Office of Industrial Technologies (ITP) web site. http://www1.eere.energy.gov/industry/
   - Sempra Energy – Southern California Gas Company web site. www.socalgas.com
   - California Energy Commission web site

     www.energy.ca.gov

Appendix 1

Steam Tables

The following link will allow the user to calculate steam properties

If necessary please copy and paste this link to your Internet browser

http://www.spiraxsarco.com/us/resources/steam-tables.asp

Definition of Steam Properties

- *p – Pressure (psia)*
- *T* - Temperature (deg. F)
- *v* – Specific volume (ft^3/lbm)
- *u* – Internal energy (Btu/lbm)
- *h* – Total enthalpy or heat (Btu/lbm)
- *s* – Entropy (Btu/lb-F)

The saturation temperature is shown with each pressure in red.

Superheated Water (H2O) Table												
deg-F	ft^3/lbm	Btu/lbm	Btu/lbm	Btu/lbm	ft^3/lbm	Btu/lbm	Btu/lbm	Btu/lbm	ft^3/lbm	Btu/lbm	Btu/lbm	Btu/lbm
T	*p* = 1.0 psia (101.70 F)				*p* = 5.0 psia (162.21 F)				*p* = 10.0 psia (193.19 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	333.6	1044.0	1105.8	1.9779	73.53	1063.0	1131.0	1.8441	38.42	1072.2	1143.3	1.7877
200	392.5	1077.5	1150.1	2.0508	78.15	1076.3	1148.6	1.8715	38.85	1074.7	1146.6	1.7927
240	416.4	1091.2	1168.3	2.0775	83.00	1090.3	1167.1	1.8987	41.32	1089.0	1165.5	1.8205
280	440.3	1105.0	1186.5	2.1028	87.83	1104.3	1185.5	1.9244	43.77	1103.3	1184.3	1.8467
320	464.2	1118.9	1204.6	2.1269	92.64	1118.3	1204.0	1.9487	46.20	1117.6	1203.1	1.8714
360	488.1	1132.9	1223.2	2.1500	97.45	1132.4	1222.6	1.9719	48.62	1131.8	1221.8	1.8948
400	511.9	1147.0	1241.8	2.1720	102.24	1146.6	1241.2	1.9941	51.03	1146.1	1240.5	1.9171
440	535.8	1161.2	1260.4	2.1932	107.03	1160.9	1259.9	2.0154	53.44	1160.5	1259.3	1.9385
500	571.5	1182.8	1288.5	2.2235	114.20	1182.5	1288.2	2.0458	57.04	1182.2	1287.7	1.9690
600	631.1	1219.3	1336.1	2.2706	126.15	1219.1	1335.8	2.0930	63.03	1218.9	1335.5	2.0164
700	690.7	1256.7	1384.5	2.3142	138.08	1256.5	1384.3	2.1367	69.01	1256.3	1384.0	2.0601
800	750.3	1294.9	1433.7	2.3550	150.01	1294.7	1433.5	2.1775	74.98	1294.6	1433.3	2.1009
1000	869.5	1373.9	1534.8	2.4294	173.86	1373.9	1534.7	2.2520	86.91	1373.8	1534.6	2.1755
1200	988.6	1456.7	1639.6	2.4967	197.70	1456.6	1639.5	2.3192	98.84	1456.5	1639.4	2.2428
1400	1107.7	1543.1	1748.1	2.5584	221.54	1543.1	1748.1	2.3810	110.76	1543.0	1748.0	2.3045
T	*p* = 14.696 psia (211.99 F)				*p* = 20 psia (227.96 F)				*p* = 40 psia (267.26 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	26.80	1077.6	1150.5	1.7567	20.09	1082.0	1156.4	1.7320	10.501	1092.3	1170.0	1.6767
240	28.00	1087.9	1164.0	1.7764	20.47	1086.5	1162.3	1.7405				
280	29.69	1102.4	1183.1	1.8030	21.73	1101.4	1181.8	1.7676	10.711	1097.3	1176.6	1.6857
320	31.36	1116.8	1202.1	1.8280	22.98	1116.0	1201.0	1.7930	11.360	1112.8	1196.9	1.7124
360	33.02	1131.2	1221.0	1.8516	24.21	1130.6	1220.1	1.8168	11.996	1128.0	1216.8	1.7373
400	34.67	1145.6	1239.9	1.8741	25.43	1145.1	1239.2	1.8395	12.623	1143.0	1236.4	1.7606
440	36.31	1160.1	1258.8	1.8956	26.64	1159.6	1258.2	1.8611	13.243	1157.8	1255.8	1.7828
500	38.77	1181.8	1287.3	1.9263	28.46	1181.5	1286.8	1.8919	14.164	1180.1	1284.9	1.8140
600	42.86	1218.6	1335.2	1.9737	31.47	1218.4	1334.8	1.9395	15.685	1217.3	1333.4	1.8621

T	p = 14.696 psia (211.99 F)				p = 20 psia (227.96 F)				p = 40 psia (267.26 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
700	46.93	1256.1	1383.8	2.0175	34.47	1255.9	1383.5	1.9834	17.196	1255.1	1382.4	1.9063
800	51.00	1294.4	1433.1	2.0584	37.46	1294.3	1432.9	2.0243	18.701	1293.7	1432.1	1.9474
1000	59.13	1373.7	1534.5	2.1330	43.44	1373.5	1534.3	2.0989	21.70	1373.1	1533.8	2.0223
1200	67.25	1456.5	1639.3	2.2003	49.41	1456.4	1639.2	2.1663	24.69	1456.1	1638.9	2.0897
1400	75.36	1543.0	1747.9	2.2621	55.37	1542.9	1747.9	2.2281	27.68	1542.7	1747.6	2.1515
1600	83.47	1633.2	1860.2	2.3194	61.33	1633.2	1860.1	2.2854	30.66	1633.0	1859.9	2.2089

T	p = 60 psia (292.73 F)				p = 80 psia (312.07 F)				p = 100 psia (327.86 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	7.177	1098.3	1178.0	1.6444	5.474	1102.6	1183.6	1.6214	4.434	1105.8	1187.8	1.6034
320	7.485	1109.5	1192.6	1.6634	5.544	1106.0	1188.0	1.6271				
360	7.924	1125.3	1213.3	1.6893	5.886	1122.5	1209.7	1.6541	4.662	1119.7	1205.9	1.6259
400	8.353	1140.8	1233.5	1.7134	6.217	1138.5	1230.6	1.6790	4.934	1136.2	1227.5	1.6517
440	8.775	1156.0	1253.4	1.7360	6.541	1154.2	1251.0	1.7022	5.199	1152.3	1248.5	1.6755
500	9.399	1178.6	1283.0	1.7678	7.017	1177.2	1281.1	1.7346	5.587	1175.7	1279.1	1.7085
600	10.425	1216.3	1332.1	1.8165	7.794	1215.3	1330.7	1.7838	6.216	1214.2	1329.3	1.7582
700	11.440	1254.4	1381.4	1.8609	8.561	1253.6	1380.3	1.8285	6.834	1252.8	1379.2	1.8033
800	12.448	1293.0	1431.2	1.9022	9.321	1292.4	1430.4	1.8700	7.445	1291.8	1429.6	1.8449
1000	14.454	1372.7	1533.2	1.9773	10.831	1372.3	1532.6	1.9453	8.657	1371.9	1532.1	1.9204
1200	16.452	1455.8	1638.5	2.0448	12.333	1455.5	1638.1	2.0130	9.861	1455.2	1637.7	1.9882
1400	18.445	1542.5	1747.3	2.1067	13.830	1542.3	1747.0	2.0749	11.060	1542.0	1746.7	2.0502
1600	20.44	1632.8	1859.7	2.1641	15.324	1632.6	1859.5	2.1323	12.257	1632.4	1859.3	2.1076
1800	22.43	1726.7	1975.5	2.2179	16.818	1726.5	1975.5	2.1861	13.452	1726.4	1975.3	2.1614
2000	24.41	1824.0	2095.1	2.2685	18.310	1823.9	2094.9	2.2367	14.647	1823.7	2094.8	2.2121

T	*p* = 120 psia (341.30 F)				*p* = 140 psia (353.08 F)				*p* = 160 psia (363.60 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	3.730	1108.3	1191.1	1.5886	3.221	1110.3	1193.8	1.5761	2.836	1112.0	1196.0	1.5651
360	3.844	1116.7	1202.0	1.6021	3.259	1113.5	1198.0	1.5812				
400	4.079	1133.8	1224.4	1.6288	3.466	1131.4	1221.2	1.6088	3.007	1128.8	1217.8	1.5911
450	4.360	1154.3	1251.2	1.6590	3.713	1152.4	1248.6	1.6399	3.228	1150.5	1246.1	1.6230
500	4.633	1174.2	1277.1	1.6868	3.952	1172.7	1275.1	1.6682	3.440	1171.2	1273.0	1.6518
550	4.900	1193.8	1302.6	1.7127	4.184	1192.6	1300.9	1.6944	3.646	1191.3	1299.2	1.6784
600	5.164	1213.2	1327.8	1.7371	4.412	1212.1	1326.4	1.7191	3.848	1211.1	1325.0	1.7034
700	5.682	1252.0	1378.2	1.7825	4.860	1251.2	1377.1	1.7648	4.243	1250.4	1376.0	1.7494
800	6.195	1291.2	1428.7	1.8243	5.301	1290.5	1427.9	1.8068	4.631	1289.9	1427.0	1.7916
1000	7.208	1371.5	1531.5	1.9000	6.173	1371.0	1531.0	1.8827	5.397	1370.6	1530.4	1.8677
1200	8.213	1454.9	1637.3	1.9679	7.036	1454.6	1636.9	1.9507	6.154	1454.3	1636.5	1.9358
1400	9.214	1541.8	1746.4	2.0300	7.895	1541.6	1746.1	2.0129	6.906	1541.4	1745.9	1.9980
1600	10.212	1632.3	1859.0	2.0875	8.752	1632.1	1858.8	2.0704	7.656	1631.9	1858.6	2.0556
1800	11.209	1726.2	1975.1	2.1413	9.607	1726.1	1975.0	2.1242	8.405	1725.9	1974.8	2.1094
2000	12.205	1823.6	2094.6	2.1919	10.461	1823.5	2094.5	2.1749	9.153	1823.3	2094.3	2.1601

T	*p* = 180 psia (373.13 F)				*p* = 200 psia (381.86 F)				*p* = 225 psia (391.87 F)			
	v	*u*	*h*	*s*	*v*	*u*	*h*	*s*	*v*	*u*	*h*	*s*
Sat.	2.533	1113.4	1197.8	1.5553	2.289	1114.6	1199.3	1.5464	2.043	1115.8	1200.8	1.5365
400	2.648	1126.2	1214.4	1.5749	2.361	1123.5	1210.8	1.5600	2.073	1119.9	1206.2	1.5427
450	2.850	1148.5	1243.4	1.6078	2.548	1146.4	1240.7	1.5938	2.245	1143.8	1237.3	1.5779
500	3.042	1169.6	1270.9	1.6372	2.724	1168.0	1268.8	1.6239	2.405	1165.9	1266.1	1.6087
550	3.228	1190.0	1297.5	1.6642	2.893	1188.7	1295.7	1.6512	2.588	1187.0	1293.5	1.6366
600	3.409	1210.0	1323.5	1.6893	3.058	1208.9	1322.1	1.6767	2.707	1207.5	1320.2	1.6624
700	3.763	1249.6	1374.9	1.7357	3.379	1248.8	1373.8	1.7234	2.995	1247.7	1372.4	1.7095
800	4.110	1289.3	1426.2	1.7781	3.693	1288.6	1425.3	1.7660	3.276	1287.8	1424.2	1.7523
900	4.453	1329.4	1477.7	1.8175	4.003	1328.9	1477.1	1.8055	3.553	1328.3	1476.2	1.7920
1000	4.793	1370.2	1529.8	1.8545	4.310	1369.8	1529.3	1.8425	3.827	1369.3	1528.6	1.8292
1200	5.467	1454.0	1636.1	1.9227	4.918	1453.7	1635.7	1.9109	4.369	1453.4	1635.3	1.8977
1400	6.137	1541.2	1745.6	1.9849	5.521	1540.9	1745.3	1.9732	4.906	1540.7	1744.9	1.9600
1600	6.804	1631.7	1858.4	2.0425	6.123	1631.6	1858.2	2.0308	5.441	1631.3	1857.9	2.0177
1800	7.470	1725.8	1974.6	2.0964	6.722	1725.6	1974.4	2.0847	5.975	1725.4	1974.2	2.0716
2000	8.135	1823.2	2094.2	2.1470	7.321	1823.0	2094.0	2.1354	6.507	1822.9	2093.8	2.1223

T	p = 250 psia (401.04 F)				p = 275 psia (409.52 F)				p = 300 psia (417.43 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	1.8448	1116.7	1202.1	1.5274	1.6813	1117.5	1203.1	1.5192	1.5442	1118.2	1203.9	1.5115
450	2.002	1141.1	1233.7	1.5632	1.8026	1138.3	1230.0	1.5495	1.6361	1135.4	1226.2	1.5365
500	2.150	1163.8	1263.3	1.5948	1.9407	1161.7	1260.4	1.5820	1.7662	1159.5	1257.5	1.5701
550	2.290	1185.3	1291.3	1.6233	2.071	1183.6	1289.0	1.6110	1.8878	1181.9	1286.7	1.5997
600	2.426	1206.1	1318.3	1.6494	2.196	1204.7	1316.4	1.6376	2.004	1203.2	1314.5	1.6266
650	2.558	1226.5	1344.9	1.6739	2.317	1225.3	1343.2	1.6623	2.117	1224.1	1341.6	1.6516
700	2.688	1246.7	1371.1	1.6970	2.436	1245.7	1369.7	1.6856	2.227	1244.6	1368.3	1.6751
800	2.943	1287.0	1423.2	1.7401	2.670	1286.2	1422.1	1.7289	2.442	1285.4	1421.0	1.7187
900	3.193	1327.6	1475.3	1.7799	2.898	1327.0	1474.5	1.7689	2.653	1326.3	1473.6	1.7589
1000	3.440	1368.7	1527.9	1.8172	3.124	1368.2	1527.2	1.8064	2.860	1367.7	1526.5	1.7964
1200	3.929	1453.0	1634.8	1.8858	3.570	1452.3	1634.3	1.8751	3.270	1452.2	1633.8	1.8653
1400	4.414	1540.4	1744.6	1.9483	4.011	1540.1	1744.2	1.9376	3.675	1539.8	1743.8	1.9279
1600	4.896	1631.1	1857.6	2.0060	4.450	1630.9	1857.3	1.9954	4.078	1630.7	1857.0	1.9857
1800	5.376	1725.2	1974.0	2.0599	4.887	1725.0	1973.7	2.0493	4.479	1724.9	1973.5	2.0396
2000	5.856	1822.7	2093.6	2.1106	5.323	1822.5	2093.4	2.1000	4.879	1822.3	2093.2	2.0904
T	p = 350 psia (431.82 F)				p = 400 psia (444.70 F)				p = 450 psia (456.39 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	1.3267	1119.0	1204.9	1.4978	1.1620	1119.5	1205.5	1.4856	1.0326	1119.6	1205.6	1.4746
450	1.3733	1129.2	1218.2	1.5125	1.1745	1122.6	1209.6	1.4901				
500	1.4913	1154.9	1251.5	1.5482	1.2843	1150.1	1245.2	1.5282	1.1226	1145.1	1238.5	1.5097
550	1.5998	1178.3	1281.9	1.5790	1.3833	1174.6	1277.0	1.5605	1.2146	1170.7	1271.9	1.5436
600	1.7025	1200.3	1310.6	1.6068	1.4760	1197.3	1306.6	1.5892	1.2996	1194.3	1302.5	1.5732
650	1.8013	1221.6	1338.3	1.6323	1.5645	1219.1	1334.9	1.6153	1.3803	1216.6	1331.5	1.6000
700	1.8975	1242.5	1365.4	1.6562	1.6503	1240.4	1362.5	1.6397	1.4580	1238.2	1359.6	1.6248
800	2.085	1283.8	1418.8	1.7004	1.8163	1282.1	1416.6	1.6844	1.6077	1280.5	1414.4	1.6701
900	2.267	1325.0	1471.8	1.7409	1.9776	1323.7	1470.1	1.7252	1.7524	1322.4	1468.3	1.7113
1000	2.446	1366.6	1525.0	1.7787	2.1360	1365.5	1523.6	1.7632	1.8941	1364.4	1522.2	1.7495
1200	2.799	1451.5	1632.8	1.8478	2.4460	1450.7	1631.8	1.8327	2.1720	1450.0	1630.8	1.8192
1400	3.148	1539.3	1743.1	1.9106	2.7520	1538.7	1742.4	1.8956	2.4440	1538.1	1741.7	1.8823
1600	3.494	1630.2	1856.5	1.9685	3.0550	1629.8	1855.9	1.9535	2.7150	1629.3	1855.4	1.9403
1800	3.838	1724.5	1973.1	2.0225	3.3570	1724.1	1972.6	2.0076	2.9830	1723.7	1972.1	1.9944
2000	4.182	1822.0	2092.8	2.0733	3.6580	1821.6	2092.4	2.0584	3.2510	1821.3	2092.0	2.0453

T	p = 500 psia (467.13 F)				p = 600 psia (486.33 F)				p = 700 psia (503.23 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	0.9283	1119.4	1205.3	1.4645	0.7702	1118.6	1204.1	1.4464	0.6558	1117.0	1202.0	1.4305
500	0.9924	1139.7	1231.5	1.4923	0.7947	1128.0	1216.2	1.4592				
550	1.0792	1166.7	1266.6	1.5279	0.8749	1158.2	1255.4	1.4990	0.7275	1149.0	1243.2	1.4723
600	1.1583	1191.1	1298.3	1.5585	0.9456	1184.5	1289.5	1.5320	0.7929	1177.5	1280.2	1.5081
650	1.2327	1214.0	1328.0	1.5860	1.0109	1208.6	1320.9	1.5609	0.8520	1203.1	1313.4	1.5387
700	1.3040	1236.0	1356.7	1.6112	1.0727	1231.5	1350.6	1.5872	0.9073	1226.9	1344.4	1.5661
800	1.4407	1278.8	1412.1	1.6571	1.1900	1275.4	1407.6	1.6343	1.0109	1272.0	1402.9	1.6145
900	1.5723	1321.0	1466.5	1.6987	1.3021	1318.4	1462.9	1.6766	1.1089	1315.6	1459.3	1.6576
1000	1.7008	1363.3	1520.7	1.7371	1.4108	1361.2	1517.8	1.7155	1.2036	1358.9	1514.9	1.6970
1100	1.8271	1406.0	1575.1	1.7731	1.5173	1404.2	1572.7	1.7519	1.2960	1402.4	1570.2	1.7337
1200	1.9518	1449.2	1629.8	1.8072	1.6222	1447.7	1627.8	1.7861	1.3868	1446.2	1625.8	1.7682
1400	2.1980	1537.6	1741.0	1.8704	1.8289	1536.5	1739.5	1.8497	1.5652	1535.3	1738.1	1.8321
1600	2.4420	1628.9	1854.8	1.9285	2.0330	1628.0	1853.7	1.9080	1.7409	1627.1	1852.6	1.8906
1800	2.6840	1723.3	1971.7	1.9827	2.2360	1722.6	1970.8	1.9622	1.9152	1721.8	1969.9	1.9449
2000	2.9260	1820.9	2091.6	2.0335	2.4380	1820.2	2090.8	2.0131	2.0887	1819.5	2090.1	1.9958

T	p = 800 psia (518.36 F)				p = 1000 psia (544.75 F)				p = 1250 psia (572.56 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat.	0.5691	1115.0	1199.3	1.4160	0.4459	1109.9	1192.4	1.3903	0.3454	1101.7	1181.6	1.3619
550	0.6154	1138.8	1229.9	1.4469	0.4534	1114.8	1198.7	1.3966				
600	0.6776	1170.1	1270.4	1.4861	0.5140	1153.7	1248.8	1.4450	0.3786	1129.0	1216.6	1.3954
650	0.7324	1197.2	1305.6	1.5186	0.5637	1184.7	1289.1	1.4822	0.4267	1167.2	1266.0	1.4410
700	0.7829	1222.1	1338.0	1.5471	0.6080	1212.0	1324.6	1.5135	0.4670	1198.4	1306.4	1.4767
750	0.8306	1245.7	1368.6	1.5730	0.6490	1237.2	1357.3	1.5412	0.5030	1226.1	1342.4	1.5070
800	0.8764	1268.5	1398.2	1.5969	0.6878	1261.2	1388.5	1.5664	0.5364	1251.8	1375.8	1.5341
900	0.9640	1312.9	1455.6	1.6408	0.7610	1307.3	1448.1	1.6120	0.5984	1300.0	1438.4	1.5820
1000	1.0482	1356.7	1511.9	1.6807	0.8306	1352.2	1505.9	1.6530	0.6563	1346.4	1498.2	1.6244
1100	1.1300	1400.5	1567.8	1.7178	0.8976	1396.8	1562.9	1.6908	0.7116	1392.0	1556.6	1.6631
1200	1.2102	1444.6	1623.8	1.7526	0.9630	1441.5	1619.7	1.7261	0.7652	1437.5	1614.5	1.6991
1400	1.3674	1534.2	1736.6	1.8167	1.0905	1531.9	1733.7	1.7909	0.8689	1529.0	1730.0	1.7648
1600	1.5218	1626.2	1851.5	1.8754	1.2152	1624.4	1849.3	1.8499	0.9699	1622.2	1846.5	1.8243
1800	1.6749	1721.0	1969.0	1.9298	1.3384	1719.5	1967.2	1.9046	1.0693	1717.6	1965.0	1.8791
2000	1.8271	1818.8	2089.3	1.9808	1.4608	1817.4	2087.7	1.9557	1.1678	1815.7	2085.8	1.9304

T	p = 1500 psia (596.39 F)				p = 1750 psia (617.31 F)				p = 2000 psia (636.00 F)			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat	0.2769	1091.8	1168.7	1.3359	0.2268	1080.2	1153.7	1.3109	0.18813	1066.6	1136.3	1.2861
600	0.2816	1096.6	1174.8	1.3416								
650	0.3329	1147.0	1239.4	1.4012	0.2627	1122.5	1207.6	1.3603	0.2057	1091.1	1167.2	1.3141
700	0.3716	1183.4	1286.6	1.4429	0.3022	1166.7	1264.6	1.4106	0.2487	1147.7	1239.8	1.3782
750	0.4049	1214.1	1326.5	1.4767	0.3341	1201.3	1309.5	1.4485	0.2803	1187.3	1291.1	1.4216
800	0.4350	1241.8	1362.5	1.5058	0.3622	1231.3	1348.6	1.4802	0.3071	1220.1	1333.8	1.4562
850	0.4631	1267.7	1396.2	1.5320	0.3878	1258.8	1384.4	1.5081	0.3312	1249.5	1372.0	1.4860
900	0.4897	1292.5	1428.5	1.5562	0.4119	1284.8	1418.2	1.5334	0.3534	1276.8	1407.6	1.5126
1000	0.5400	1340.4	1490.3	1.6001	0.4569	1334.3	1482.3	1.5789	0.3945	1328.1	1474.1	1.5598
1100	0.5876	1387.2	1550.3	1.6399	0.4990	1382.2	1543.8	1.6197	0.4325	1377.2	1537.2	1.6017
1200	0.6334	1433.5	1609.3	1.6765	0.5392	1429.4	1604.0	1.6571	0.4685	1425.2	1598.6	1.6398
1400	0.7213	1526.1	1726.3	1.7431	0.6158	1523.1	1722.6	1.7245	0.5368	1520.2	1718.8	1.7082
1600	0.8064	1619.9	1843.7	1.8031	0.6896	1617.6	1841.0	1.7850	0.6020	1615.4	1838.2	1.7692
1800	0.8899	1715.7	1962.7	1.8582	0.7617	1713.9	1960.5	1.8404	0.6656	1712.0	1958.3	1.8249
2000	0.9725	1814.0	2083.9	1.9096	0.8330	1812.3	2082.0	1.8919	0.7284	1810.6	2080.2	1.8765

T	p = 2500 psia (668.31 F)				p = 3000 psia (695.52 F)				p = 3500 psia			
	v	u	h	s	v	u	h	s	v	u	h	s
Sat	0.13059	1031.0	1091.4	1.2327	0.08404	968.8	1015.5	1.1575				
650									0.02491	663.5	679.7	0.8630
700	0.16839	1098.7	1176.6	1.3073	0.09771	1003.9	1058.1	1.1944	0.03058	759.5	779.3	0.9506
750	0.2030	1155.2	1249.1	1.3686	0.14831	1114.7	1197.1	1.3122	0.10460	1058.4	1126.1	1.2440
800	0.2291	1195.7	1301.7	1.4112	0.17572	1167.6	1265.2	1.3675	0.13626	1134.7	1223.0	1.3226
850	0.2513	1229.5	1345.8	1.4456	0.19731	1207.7	1317.2	1.4080	0.15818	1183.4	1285.9	1.3716
900	0.2712	1259.5	1385.4	1.4752	0.2160	1241.8	1361.7	1.4414	0.17625	1222.4	1336.5	1.4096
950	0.2896	1288.2	1422.2	1.5018	0.2328	1272.7	1402.0	1.4705	0.19214	1256.4	1380.8	1.4416
1000	0.3069	1315.2	1457.2	1.5262	0.2485	1301.7	1439.6	1.4967	0.2066	1287.6	1421.4	1.4699
1100	0.3393	1366.8	1523.8	1.5704	0.2772	1356.2	1510.1	1.5434	0.2328	1345.2	1496.0	1.5193
1200	0.3696	1416.7	1587.7	1.6101	0.3036	1408.0	1576.6	1.5848	0.2566	1399.2	1565.3	1.5624
1400	0.4261	1514.2	1711.3	1.6804	0.3524	1508.1	1703.7	1.6571	0.2997	1501.9	1696.1	1.6368
1600	0.4795	1610.2	1832.6	1.7424	0.3978	1606.3	1827.1	1.7201	0.3395	1601.7	1821.6	1.7010
1800	0.5312	1708.2	1954.0	1.7986	0.4416	1704.5	1949.6	1.7769	0.3776	1700.8	1945.4	1.7583
2000	0.5820	1807.2	2076.4	1.8506	1.4844	1803.9	2072.8	1.8291	0.4147	1800.6	2069.2	1.8108

T	p = 4000 psia				p = 5000 psia				p = 6000 psia			
	v	u	h	s	v	u	h	s	v	u	h	s
650	0.02447	657.7	675.8	0.8574	0.02377	648.0	670.0	0.8482	0.01222	640.0	665.8	0.8405
700	0.02867	742.1	763.4	0.9345	0.02676	721.8	746.6	0.9156	0.02563	708.1	736.5	0.9028
750	0.06331	960.7	1007.5	1.1395	0.03364	821.4	852.6	1.0049	0.02978	788.6	821.7	0.9746
800	0.10522	1095.0	1172.9	1.2740	0.05932	987.2	1042.1	1.1583	0.03942	896.9	940.7	1.0708
850	0.12833	1156.5	1251.5	1.3352	0.08556	1092.7	1171.9	1.2596	0.05818	1018.8	1083.4	1.1820
900	0.14622	1201.5	1309.7	1.3789	0.10385	1155.1	1251.1	1.3190	0.07588	1102.9	1187.2	1.2599
950	0.16151	1239.2	1358.8	1.4144	0.11853	1202.2	1311.9	1.3629	0.09008	1162.0	1262.0	1.3140
1000	0.17520	1272.9	1402.6	1.4449	0.13120	1242.0	1363.4	1.3988	0.10207	1209.1	1322.4	1.3561
1100	0.19954	1333.9	1481.6	1.4973	0.15302	1310.6	1452.2	1.4577	0.12218	1286.4	1422.1	1.4222
1200	0.2213	1390.1	1553.9	1.5423	0.17199	1371.6	1530.8	1.5066	0.13927	1352.7	1507.3	1.4752
1300	0.2414	1443.7	1622.4	1.5823	0.18918	1428.6	1603.7	1.5493	0.15453	1413.3	1584.9	1.5206
1400	0.2603	1495.7	1688.4	1.6188	0.20517	1483.2	1673.0	1.5876	0.16854	1470.5	1657.6	1.5608
1600	0.2959	1597.1	1816.1	1.6841	0.2348	1587.9	1805.2	1.6551	0.19420	1578.7	1794.3	1.6307
1800	0.3296	1697.1	1941.1	1.7420	0.2626	1689.8	1932.7	1.7142	0.21801	1682.4	1924.5	1.6910
2000	0.3625	1797.3	2065.6	1.7948	0.2895	1790.8	2058.6	1.7676	0.24087	1784.3	2051.7	1.7450